A Laser Based Micrometeorite Accelerator for Impact Studies.

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Abstract: Space weathering of rocky and icy bodies in the inner and outer solar system causes chemical and physical changes to occur. Sources of space weathering include medium velocity (> 3 km/sec) micro-meteorite impact events, solar wind electron and ion bombardment, magnetospheric plasma interactions, cosmic rays, and thermal excursions [1]. Investigating these energetic and thermal processes at a fundamental level is of utmost importance in order to 1) design new shielding materials for future human exploration of distant surfaces (planets and moons) in the solar system and beyond; 2) process and utilize *in situ* resources; 3) understand life sustainability and survival of biomolecules in harsh conditions.

In the past, interactions with energetic ions have been easily simulated in the laboratory. However, developing table-top micrometeorite bombardment systems remains an expensive and challenging task. To help mediate these concerns, a laser-based technique will be utilized [2-4].

The experimental design of the laser induced micro-particle accelerator (LIMA) consists of two high energy pulsed Nd:YAG lasers. The first is a 1064 nm wavelength laser that will be used to launch the micro-particles off a custom substrate toward the particle target of interest, e.g. polymer or regolith. The second laser is centered at 532 nm and will pass through a polarized dependent optical delay path to aid in the velocity measurements. The substrate target and the micro-particles will be held in position about 1 mm away from each other. As a proof of concept study, micro-particles were accelerated towards a clear polymer, seen in *Figure 1.* This image is of the implanted micro-particles on the thin polymer magnified at 50x. From this figure, a depth profile of the implanted micro-particles is clearly observed.

The experimental design of LIMA, its first results, and future use of LIMA under ultrahigh high vacuum conditions that simulate micrometeorite impact events in realistic space environments will be discussed. Specifically, a primary goal of the REVEALS project is to directly measure the production of gas phase water, hydroxyl, and hydrogen atoms in a simulated impact event. Knowledge of the production rates branching ratios, kinetic energies, and the internal energy distribution (rotational, vibrational, and electronic) will have direct assistance with interpretations of observations, and prediction of water locations for resource utilization.

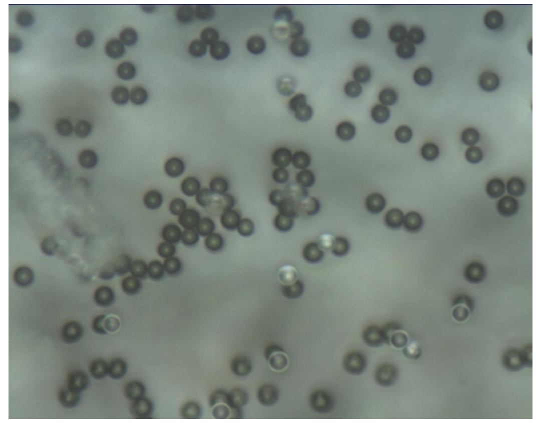

Figure 1: 50x magnified image shows the depth profile of the micro-particles after they have been accelerated via laser ablation towards a clear polymer.

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References: [1] Bennett *et al. Chem. Rev.* 2013, **113**, 9086; [2] Lee *et al. Nat. Commun*. 2012, **3**, Article number: 116; [3] Lee *et al. Science* 2014, **346**, 1092; [4] Veysset *et al*. *Sci. Rep.* 2016, **6**, Article number: 25577.